REMARKS

Claims 1, 2, 4, 6, 8-12, 16, 20-22, 24, 30, 32 and 34, are all claims presently pending in the application. Claims 7, 15, 17-19, 23, 25, 28, 29, 31, 33, 35-37, and 57-64 have been canceled without prejudice or disclaimer. Independent Claims 1, 12, 22, and 30 have been amended.

Claims 1, 2, 4, 6-12, 16, 20-22, 24, 30, 32 and 34, stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Edelstein, et al. (U.S. Pat. No. 6,181,012 B1) or Dubin (U.S. Pat. No. 6,249,055 B1) taken with any Kato (Jap. No. 63-262437), Oyama (Jap. No. 3-285,035), Yamasaki, et al. (U.S. Pat. No. 4,559,200), and further in view of Tsuji, et al. (U.S. Pat. No. 5,004,520). Reconsideration is respectfully requested. These rejections are respectfully traversed in view of the following discussion.

These rejections are respectfully traversed in view of the following discussion.

It is noted that the amendments are made only to more particularly define the invention and <u>not</u> for distinguishing the invention over the prior art, for narrowing the scope of the claims, or for any reason related to a statutory requirement for patentability.

It is further noted that, notwithstanding any claim amendments made herein, Applicant's intent is to encompass equivalents of all claim elements, even if amended herein or later during prosecution.

I. THE CLAIMED INVENTION

Applicant's invention, as disclosed and claimed, for example by independent claim 1, is directed to an electrically conductive layer including a copper alloy which includes at least one of Ag, As, P, Si, Bi, Sb, and Ti at not less than 0.1 percent by weight, so as to increase a crystal grain size and reduce crystal grain boundaries.

The copper alloy further includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Importantly, at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper. (See Page 13, lines 5-24; Page 14, lines 18-21; Page 16, line 10-Page 17, line 7; Page 22, line 5-Page 23, line 5; Page 29, line 21-Page 34, line 14; Page 38, line 25-Page 40, line 3; Page 41, line 10-Page 43, line 5; Page 58, lines 5-15; and Page 60, line 1-Page 61, line 6).

The other embodiments, as defined by independent claims 12, 22 and 30, recite somewhat similar limitations.

As mentioned above, an important aspect of the invention is that at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper. Another aspect includes the copper alloy, which further includes at least one of Ag, As, Bi, P, Sb, Si and Ti at not less than 0.1 percent by weight, so as to increase a crystal grain size and reduce crystal grain boundaries. A further aspect includes the copper alloy, which includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. As indicated, the copper alloy has relatively large crystal grain sizes and reduced crystal grain boundaries. This allows the crystal grain boundaries to be formed in vertical direction to a longitudinal

direction of the interconnection or a direction along which a current flows. (See Page 26, lines 8-20; and Page 43, line 14-Page 44, line 9).

As a result of this invention, the resultant structure suppresses the mass-transfer of copper through the copper alloy and prevent the resistivity of the copper alloy from becoming too high. Thus, a reduction in electromigration of an interconnection layer in a semiconductor device is produced decreasing the probability of disconnection and cracking of the interconnection layer, thereby improving the reliability and productivity of the semiconductor device. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 17-24; Page 26, lines 8-20; and Page 44, lines 1-9).

II. 35 U.S.C. § 112, Second Paragraph Rejection, and 37 C.F.R. 1.75(c) Objection

Applicant has amended the claims in a manner believed fully responsive to all points raised by the Examiner with regard to the 35 U.S.C. § 112, second Paragraph Rejection and the Examiner's objections under 37 C.F.R. 1.75(c).

In view of the foregoing, the Examiner is respectfully requested to withdraw these rejections and objections.

III. THE PRIOR ART REJECTION

A. The § 103(a) Rejection over Edelstein or Dubin in view of Kato, Oyama, or Yamasaki, and further in view of Tsuji

First, the references, separately, or in combination, fail to teach, disclose or provide a reason or motivation for being combined.

In particular, Edelstein, et al. ("Edelstein") provides a copper alloy interconnection

structure with an improved resistivity to electromigrationand improved adhesiveness property. (See Edelstein at Abstract; Column 1, lines 5-15; and Column 6, lines 10-23). Dubin ("Dubin") provides a copper or copper-alloy interconnection structure free of any copper diffusion and having a highly anti-corrosion property. (See Dubin at Abstract; Column 1, lines 5-10; and Column 3, lines 55-62). Kato ("Kato") provides a copper alloy superior in conductivity and mechanical strengths, for example, bending strength and tensile strength. (See Kato at Abstract). Oyama ("Oyama") provides a copper alloy superior in anti-migration property and strength. (See Oyama at Abstract). Yamasaki ("Yamasaki") provides an electrically conductive copper alloy superior in mechanical strength and rigidity. (See Yamasaki at Abstract; Column 1, lines 5-15; Column 2, lines 10-31 and 53-60). Tsuji, et al. ("Tsuji") is to a film carrier improving a strength and a thermal stability of the leads. (See Tsuji at Abstract; Column 1, lines 20-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1).

As mentioned above, the issues of Edelstein and Dubin are irrelevant to the issues of Kato, Oyama, Yamasaki and Tsuji.

The electromigrationdisclosed in Edelstein is a phenomenon that metal components move over and through a non-metal catalyst, wherein the metal components are in a metal state which exhibits electrical conductivity before and after the movement.

The migration disclosed in Oyama is quite a different phenomenon from the electromigrationdisclosed in Edelstein. The migration disclosed in Oyama is a different phenomenon of an electric-field corrosion of paired conductors through a leakage of current between the paired conductors applied with the field.

Consequently, the object of Edelstein is irrelevant to the issues of Kato, Oyama,

Yamasaki and Tsuji. Further, no suggestion nor teaching exists to combine Edelstein to Kato, Oyama, Yamasaki and Tsuji. Thus, there is no motivation or reason present to combine Edelstein to Kato, Oyama, Yamasaki and Tsuji. Also the object of Dubin is irrelevant to the objects of Kato, Oyama, Yamasaki and Tsuji. Further, no suggestion nor teaching exists to combine Dubin to Kato, Oyama, Yamasaki and Tsuji. Thus, there is no motivation or reason present to combine Dubin to Kato, Oyama, Yamasaki and Tsuji.

Hence, the present invention as defined is clearly non-obvious over the above references, alone or in any combination.

Thus, Edelstein teaches away from being combined with another invention, such as, Kato, Oyama, Yamasaki or Tsuji. Similarly, Dubin also teaches away from being combined with another invention, such as, Kato, Oyama, Yamasaki or Tsuji.

Therefore, one of ordinary skill in the art would not have combined these references, absent hindsight. It is clear that the Examiner has simply read Applicant's specification and conducted a keyword search to yield Edelstein, Dubin , Kato, Oyama, Yamasaki and Tsuji. The Examiner provides no motivation or reason to combine other than to assert that "the references above nowhere teach that the combination is not permitted and in fact provide further motivation for inclusion." (See Office Action, Page 5,lines 7-22).

However, the Examiner should know that this is not the standard. That is, the Examiner cannot rely only on a negative inference to suggest the proper motivation. To the contrary, the MPEP clearly indicates a significantly positive assertion, and thus "the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggest the desirability of the combination." (See MPEP Section 2143.01).

First, as a result of the Examiner's keyword search, Applicant notes that no less than five references have been "kluged" together using impermissible hindsight to yield Applicant's invention. This on its face clearly strains the reasonableness of what "would have been obvious" at the time of Applicant's invention.

Secondly, even assuming that the references would have been combined, Edelstein does not teach or suggest the features of independent claim 1 and similar claims 12, 22 and 30, including that <u>the copper alloy includes at least one of Ag, As, Bi, P, Sb, Si and Ti at not less than 0.1 percent by weight, so as to increase a crystal grain size and reduce crystal grain boundaries.</u> Edelstein also does not teach or suggest the features of independent claim 1 and similar claims 12, 22 and 30, including that <u>the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight</u>. Edelstein further does not teach or suggest the features of independent claim 1 and similar claims 12, 22 and 30, including <u>at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper</u>. (See Page 13, lines 5-24; Page 14, lines 18-21; Page 16, line 10-Page 17, line 7; Page 22, line 5-Page 23, line 5; Page 29, line 21-Page 34, line 14; Page 38, line 25-Page 40, line 3; Page 41, line 10-Page 43, line 5; Page 58, lines 5-15; and Page 60, line 1-Page 61, line 6).

Rather Edelstein discloses a copper-alloy interconnection structure with improved resistivity to electromigrationand an improved adhesion property. In the copper-alloy interconnection structure, a seed layer is inserted between a copper interconnection layer and a barrier layer included in a dual-damascene structure. The seed layer may comprise a copper-alloy including copper in combination with at least one element selected from the group

consisting of Sn, In, Zr, Ti, C, No, O, Cl and S. The seed layer may comprise another copper-alloy including copper in combination with at least one element selected from the group consisting of Al, Mg, Be, Ca, Sr, Ba, Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Re, Si, and Ge. The seed layer may comprise still another copper-alloy including copper in combination with at least one element selected from the group consisting of B, O, N, P, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Ag, Au, Zn and Cd., incorporating a metal seed layer for providing electrical connections with an electronic device where either a copper alloy seed layer or the metal seed layer of Ag, Mo, W, or Co is sandwiched between a copper conductor body and an electronic device. (See Edelstein at Abstract; Column 1, lines 5-13; and Column 6, lines 10-23).

Further, Edelstein only teaches that copper alloy seed layers may be formed from a variety of elements. (See Column 8, lines 30-55). However, Edelstein does not provide any percentage of weight of the alloy elements, let alone, a percentage of weight of not less than 0.1 percent by weight for any of the elements..

Indeed, the Examiner indicates in the Office Action that Edelstein does not claim any specific amounts of the elements but attempts to rely on four other references to provide these amounts. (See Office Action at Pages 3 and 4). Edelstein, accordingly, does not teach Applicant's invention. For emphasis, Edelstein also does not teach or suggest at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper. Thus, Applicant traverses the assertion in the Office Action that Edelstein's copper alloy seed layer or metal seed layer can be used to produce Applicant's invention. (See Office Action, Page 3, 1st Paragraph).

Consequently, Edelstein's conventional structure is also unsuitable for effectively

producing a copper alloy with relatively large crystal grain sizes and reduced crystal grain boundaries in a current flow direction which suppress the mass-transfer of copper through the copper alloy and prevents the resistivity of the copper alloy from becoming too high. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 17-24; Page 26, lines 8-20; and Page 43, line 14-Page 44, line 9). Edelstein, therefore, does not teach, suggest or disclose including that <u>the copper alloy includes at least one of Ag, As, Bi, P, Sb, Si and Ti at not less than 0.1 percent by weight, so as to increase a crystal grain size and reduce crystal grain boundaries.</u> Edelstein also does not teach or suggest including that <u>the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight</u>. Edelstein further does not disclose, teach or suggest, including <u>at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper</u>.

Secondly, Dubin also does not teach or suggest the above features of independent claim independent claim 1 and similar claims 12, 22 and 30, including that <u>the copper alloy includes at least one of Ag, As, Bi, P, Sb, Si and Ti at not less than 0.1 percent by weight, so as to increase a crystal grain size and reduce crystal grain boundaries.</u> Dubin also does not teach or suggest the features of independent claim 1 and similar claims 12, 22 and 30, including that <u>the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight</u>. Dubin further does not teach or suggest the features of independent claim 1 and similar claims 12, 22 and 30, including <u>at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper</u>.

Rather Dubin discloses a copper or copper alloy interconnection structure free of any copper diffusion and having a high resistivity to corrosion. In a dual damascene copper-

interconnection structure, a seed layer is provided on an aluminum-alloy or magnesium-alloy layer for diffusing aluminum or magnesium into the copper interconnection. The seed layer includes an alloy of copper in combination with an element such as Mg, Zn, Sn, Ni, Pd, Ag, and Au.

However, Dubin also does not disclose, teach or suggest any percent by weight of any of these elements, let alone a percentage of weight of not less than 0.1 percent by weight for any of these elements. (See Column 5, line 45-Column 6, line 50).

Indeed, Dubin only teaches a thickness range of an alloy diffusion layer of 50-1,500Å . (See Column 5, lines 5 and 20, and 45-60; and Column 9, lines 38-45) . Dubin, accordingly, does not teach Applicant's invention. Thus, Applicant traverses the assertion in the Office Action that Dubin's copper alloy can be used to produce Applicant's invention. (See Office Action, Page 3, Paragraph 2).

It is noted that the Examiner indicated in the previous Office Action of December 4, 2002, that Dubin does not claim any specific amounts of the elements but attempts to rely on four other references to provide these amounts. (See Office Action, December 4, 2002, 3rd Page, 3rd Paragraph).

Consequently, Dubin's conventional structure is also unsuitable for effectively producing a copper alloy with relatively large crystal grain sizes and reduced crystal grain boundaries in a current flow direction which suppress the mass-transfer of copper through the copper alloy and prevents the resistivity of the copper alloy from becoming too high. (See Page 6, line 10 - Page 7, line 16; Page 13, lines 17-24; Page 26, lines 8-20; and Page 43, line 14-Page 44, line 9). Dubin, therefore, does not disclose, teach, or suggest including the above features as cited in independent claims 1, 12, 22 and 30 of Applicant's invention.

Third, Kato does not make up for the deficiencies of Edelstein or Dubin. Instead, Kato

discloses a conventional copper alloy superior in conductivity and mechanical strengths, for example, bending strength and tensile strength. The copper alloy includes 0.02-0.5% by weight of Mg for providing a mechanical strength to the copper alloy, 35-100% by weight of phosphorous ("P") with reference to Mg for improving the mechanical strength, and 0.01-0.5% by weight of Sb for improving the tensile strength and a fatigue strength. (See Kato at Abstract).

In contrast, Applicant's invention as disclosed above, includes a specific composition of elements, including at least one of Mo, Ta and W, which is significantly different than the composition of Mg, P and Sb, without any Mo, Ta and W as recited in Kato. Kato does not teach or disclose at least including at least one of Mo, Ta and W, let alone, the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Accordingly, Kato also does not disclose, teach or suggest including at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper.

Consequently, Kato's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fourth, Oyama does not make up for the deficiencies of Edelstein or Dubin. Instead, Oyama discloses a conventional copper alloy superior in anti-migration property and strength, which includes 0.1-1.0% by weight of Ti, 0.3-2.5% by weight of Ni, 1.0-3.0% of Sn, and 0.5-1.0% by weight of Zn. (See Oyama at Abstract).

In contrast, Applicant's invention as disclosed above, includes an important

composition of elements, <u>including</u> at least one of Mo, Ta and W. Applicant's composition is significantly different than Oyama's composition of Ti, Ni , Sn and Zn in a range of 0.1-3.0 percent by weight with minor elements of Fe, Cr, Co, Zr, Mg and Si at about 0.5 percent by weight <u>without</u> any Mo, Ta or W.

Oyama does <u>not</u> teach or disclose at least including at least one of Mo, Ta and W, let alone, the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Accordingly, Oyama also does not disclose, teach or suggest including at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper.

Consequently, Oyama's conventional structure is <u>also</u> unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention.

Fifth, Yamasaki does <u>not</u> make up for the deficiencies of Edelstein or Dubin. Instead, Yamasaki discloses a conventional electrically conductive copper alloy superior in mechanical strength and rigidity, which includes 0.05-1.0% by weight of Ti, 0.07-2.6% by weight of Fe, and at least one additive selected from 0.005-0.5% by weight of Mg, 0.01-0.5% by weight of Sb, 0.01-0.5% by weight of V, 0.01-0.5% by weight of Misch. Metal, 0.01-0.5% by weight of Zr, 0.01-0.5% by weight of In, 0.01-0.5% by weight of Zn, 0.01-0.5% by weight of Ni, 0.005-0.2% by weight of Al and 0.005-0.07% by weight of P. (See Yamasaki at Abstract; Column 1, lines 5-14; and Column 2, lines 10-31).

In contrast, Applicant's invention as disclosed above, includes an important composition of elements, <u>including</u> at least one of Mo, Ta and W. Applicant's composition is

significantly different than Yamasaki's composition of Fe and Ti in a range of 0.05-2.6 percent by weight with minor elements of Mg, Sb, V, Zr, In , Zn, Sn, Ni, Al and P at about 0.005-0.5 percent by weight without any Mo, Ta or W. Yamasaki does not teach or disclose at least including at least one of Mo, Ta and W, let alone, the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Accordingly, Yamasaki also does not disclose, teach or suggest including at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper.

Consequently, Yamasaki's conventional structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention. (Column 3, line 26-Column 4, line 68).

Finally, Tsuji does not make up for the deficiencies of Edelstein or Dubin. Instead, Tsuji discloses a conventional film carrier improving a strength and a thermal stability of leads, wherein a copper-alloy foil includes copper in combination with at least one additive in total amount of 0.005-1.5% by weight, selected from 0.005-0.05% by weight of P, 0.01-0.5% by weight of Co, 0.01-0.5% by weight of Al, 0.01-0.5% by weight of As, 0.01-0.5% by weight of Cd, 0.01-0.5% by weight of Fe, 0.01-0.5% by weight of In, 0.01-0.5% by weight of Mg, 0.01-0.5% by weight of Mn, 0.01-0.5% by weight of Ni, 0.01-0.5% by weight of Si, 0.01-0.5% by weight of Sn, 0.01-0.5% by weight of Te, 0.01-1% by weight of Ag, 0.01-1% by weight of Cr, 0.01-1% by weight of Hf, and 0.01-1% by weight of Zn. (See Tsuji at Abstract; Column 1, lines 5-25 and lines 48-68; Column 2, lines 8-17; Column 3, lines 52-58; and Figure 1).

In contrast, Applicant's invention as disclosed above, includes a specific composition of

elements, including at least one of Mo, Ta and W. Applicant's composition is significantly different than Tsuji's composition of one or more elements listed above, including Ag, As, P and Si at 0.01-1.0 wt % without any Mo, Ta or W. Tsuji does not teach or disclose at least including at least one of Mo, Ta and W, let alone, the copper alloy includes at least one of Mo, Ta and W in a range of not less than 0.1 percent by weight to not more than 1 percent by weight. Accordingly, Tsuji also does not disclose, teach or suggest including at least one of Mo, Ta and W being higher in density than copper is present on the crystal grain boundaries, whereby at least one of Mo, Ta and W suppresses a diffusion of copper.

Consequently, Tsuji's conventional method and related structure is also unsuitable for achieving at least two objects of the invention as indicated above, and thus does not disclose, teach or suggest the invention

For at least the reasons outlined above, Applicant respectfully submits that Edelstein, Dubin, Kato, Oyama, Yamasaki or Tsuji, separately or in combination, do not teach or suggest all of the features of independent claims 1, 12, 22, and 30, and related dependent claims 2, 4, 6, 8-11, 16, 20, 21, 24, 32 and 34, which are patentable not only by virtue of their dependency from their independent claims but also by the additional limitations they recite.

For the reasons stated above, the claimed invention is fully patentable over the cited references.

IV. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 1, 2, 4, 6, 8-12, 16, 20-22, 24, 30, 32 and 34, all the claims presently pending in the application are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested

to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

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